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ABSTRACT

Findings are presented from studies on the use of radio for teaching primary school children mathematics in Honduras and Bolivia and English as a Second Language in Lesotho. Interactive radio instruction (IRI) is so called because of the active participation of the students. Although lessons are presented by conventional radio, scripts are written to solicit responses from the children. Data from Honduras and Bolivia include both costs and measures of effectiveness, but data from Lesotho are for costs only. In Honduras, almost 200,000 children and 6,000 teachers used the radio lessons in 1990. Evaluations were conducted with three groups from different parts of the country. In Bolivia, where lessons reach about 50,000 children, evaluations have been conducted for grades 2, 3, and 4. English language instruction in Lesotho is delivered by radio to about 200,000 children; in contrast to Bolivia and Honduras, broadcasts are on government-owned, rather than privately owned, radio stations. Data suggest that IRI is a powerful instructional tool, possibly even more cost effective than textbooks or teacher training. Achievement gains in Bolivia and Honduras were striking. IRI should be considered along with textbooks and teacher training when educational planners consider options for improving basic education. Twelve tables and eight figures present study data. (Contains 16 references.) (SLD)

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THE COST-EFFECTIVENESS OF INTERACTIVE RADIO INSTRUCTION FOR IMPROVING PRIMARY SCHOOL INSTRUCTION IN HONDURAS, BOLIVIA AND LESOTHO

by

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A paper presented at the CIES Annual Conference
Pittsburgh, Pennsylvania
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Table of Contents

I. Introduction 1

II. Primary School Education in Developing Countries 2

III. Interactive Radio Instruction (IRI) 3

IV. Case studies 4

A. Honduras 4
1. Summative evaluation 4
2. Cost study 6

B. Bolivia 10
1. Background 10
2. Achievement results 11
3. Cost-effectiveness study 12

C. Lesotho 16
1. Context 17
2. Development costs 17
3. Incremental Cost 18
4. Allocation of Costs 19
5. Total Cost 20

V. Similarities and Differences of Costs in Honduras, Bolivia and Lesotho 20

VI. Comparison of IRI with Textbooks and Teacher Training . 23

VII. Conclusions 24

THE COST-EFFECTIVENESS OF INTERACTIVE RADIO INSTRUCTION FOR IMPROVING PRIMARY SCHOOL INSTRUCTION IN HONDURAS, BOLIVIA AND LESOTHO

I. Introduction

The paper presents findings from studies on the use of radio for teaching primary school children mathematics in Honduras and Bolivia, and for teaching English as a Second Language in Lesotho.[1] Data from Honduras and Bolivia include both costs and measures of effectiveness; from Lesotho there are data on costs only. The results indicate that radio can be a powerful intervention for improving the quality of primary school instruction and that the costs are relatively low and affordable. Furthermore, the results indicate that from a cost-effectiveness perspective, radio may be a better intervention than even textbooks and teacher training.

Achievement data on IRI projects have been reported widely.[2] But there have been relatively few studies on the costs of IRI programs[3] and, until 1990, there have been no cost-effectiveness studies. Such studies are particularly important for IRI, because IRI programs represent an add-on cost to the school system. Thus, it is important to know whether the increased learning gains from IRI are worth the additional costs. In this respect, IRI is no different than other interventions including textbooks and inservice teacher training in representing an add-on cost to the system. Thus, the key question should be, which of the various options or combination of options provide the greatest benefit for the least amount of additional money? It is within this context that the cost-effectiveness studies in Honduras and Bolivia are important.

The cost data for Honduras is based on a study conducted by Patricia Godoy-Kain[4]; to compare the Honduras data to that from Lesotho and Bolivia, the author of this paper re-analyzed the data. In Honduras there are good measures of both achievement gains and costs of interactive radio. For Honduras, the cost-effectiveness measure was established by measuring the <u>incremental achievement gains</u> as a ratio to the <u>incremental costs</u>.

Jamison's[5] study in Bolivia is noteworthy for two reasons. First, in addition to establishing a cost-effectiveness measure based on <u>incremental</u> achievement gains and costs, he examines cost-effectiveness in light of the <u>total achievement gains</u> and the <u>total costs</u>. Second, he assesses the achievement gains in terms of what the children learn during one year of study by giving the same test to children (both experimental and control)

in both grades 2 and 3.

Tilson's[6] study in Lesotho is of interest because it provides comparative cost data from an interactive radio program from a different continent and for teaching a different subject, English. These data will help to establish the universality of the cost figures derived in Latin America.

II. Primary School Education in Developing Countries

These studies are particularly important because of the enormous demand in developing countries for improved quality of instruction and for increasing access to schools.

A recent World Bank report[7] states that in many Third World countries "even those who complete their education have learned very little, with many students in low-income countries failing to reach either national or international standards of cognitive performance in mathematics, science, and reading comprehension."

As a result, many educators are looking to learning technologies to help provide a cost-effective means of meeting the goals of improved quality, increased access, and greater efficiency. Interactive radio instruction has received considerable attention in recent years because of its high effectiveness and low cost.

III. Interactive Radio Instruction (IRI)

IRI is a particular form of schools broadcasting that is associated with projects sponsored by the U.S. Agency for International Development beginning with the Radio Mathematics Project in Nicaragua in the mid-1970s. The term "interactive" was coined because of the active participation of the children during the radio programs. Although the lessons are presented by conventional radio, the scripts are written to solicit responses from the children every few seconds. The children talk back to the radio; they also sing, write, read, manipulate simple materials, and do physical exercises.

IRI programs are also noted for their high quality curriculum design. Extensive care is taken to incorporate the most effective learning sequences; furthermore, as the lessons are produced, classroom observation and achievement data are regularly collected and analyzed to modify and improve the lessons through a systematic formative evaluation process.

The lessons also incorporate sound pedagogical principles including active participation by the learners, distributed learning of new topics, immediate feedback on the correctness of student responses, systematic review of material already taught, and a lesson format that is lively and varied.

The lessons are also more intensive than typical schools broadcasts with anywhere from two to five 25-minute lessons every week for each subject at each grade level. The math and English lessons reported on in this paper are broadcast five times a week throughout the school year.

Approximately 600,000 children are now learning from IRI in ten countries in Latin America, Africa and Asia. The children are being taught mathematics, English as a Second Language, reading and writing in Spanish, science, and health. New programs are underway to teach environmental education and Spanish as a Second Language.

In most countries IRI is used to improve the quality of instruction. The lessons are an aid to the classroom teacher. The lessons result in increased learning under virtually all settings, but are particularly beneficial in schools with few instructional materials and underqualified teachers.

IRI is also being used to increase access to schools. In the Dominican Republic interactive radio RADECO (Radio Assisted Community-Based Education) lessons are targeted to rural communities where there are no formal schools. In these communities, young children come together for an hour every afternoon (after finishing their work in the fields) to listen to and participate in a one-hour IRI class in mathematics and language; the lessons also include some social studies and science. The children are supervised by an adult from the community. The Ministry of Education in the Dominican Republic is also conducting a study to see if RADECO lessons can help meet the need for increased access to schools in the capital of Santo Domingo. Sanguinetty's[8] study showed that if the RADECO program were implemented on a wide scale, the per student cost would be about half that of traditional schools.

IV. Case studies

A. Honduras

From 1987-1990 a new mathematics series *La Familia de los Números* was developed for children in grades 1-3 by AVANCE (Association for Socio-Economic Promotion and Development). The Radio Learning Project provided technical assistance; USAID/Honduras funded the project. The lessons focus on mental calculation skills and the application of math to everyday life. In 1990 almost 200,000 children and 6,000 teachers used the radio lessons.

1. Summative evaluation

Summative evaluations have been completed for Grades 1 and 2. The analysis of the data for Grade 3 will be complete by May

1991. The achievement data reported here is from the work of Jamesine Friend, et.al[9].

The evaluation of the radio series was complicated and made more interesting by the simultaneous introduction of new textbooks. Thus, the evaluation design sought to measure the discrete benefits of the two interventions as well as the combined impact of the new textbooks and radio lessons. The three groups are as follows:

Group A: Children with traditional instruction
Group B: Children with new textbooks
Group C: Children with new textbooks and IRI

A combined lapped-year and matched group experimental design was used. In a lapped-year design the same classes are used for both the control and experimental classes in subsequent years. That is, in the first year the children receive conventional instruction and are administered a posttest at the end of the year. In the next year, a new group of children enters those classes; this is the experimental group that receives the IRI lessons as part of the math instruction. These children take the same posttest. The advantage of a lapped-year design is that the same communities, schools and, in most cases, the same teachers, are used for both the control and experimental classes, thus, controlling for a large number of variables.

Group A was tested in 1987 before either the textbooks or radio lessons were introduced. Group C consists of the same classes, but tested one year later with a new group of children who received both the textbooks and the radio lessons. These are the two groups of the lapped-year design. The matched group is Group B from another part of the country. These classes are matched with the classes in Groups A and C. The children in Group B received the textbooks, but since the schools were not in the reception area of the radio transmitters, they did not have the radio math lessons. Groups A and B appear to be equal, based on a comparison of test results. The results of the summative evaluations for Grades 1 and 2 are shown in Figure 1.

As with other studies that have measured the impact of introducing textbooks, this evaluation shows that the new textbooks markedly increased achievement scores in Grade 1 (from 34.3% correct of Group A to 43.7% of Group B with an effect size of .43[10]). The addition of the radio lessons to the new textbooks brought the score up to 51.9% (Group C) with an effect size of .80 when compared to the traditional classes. In other words, the addition of the radio lessons about doubled the impact of just adding textbooks.

The results of the second grade evaluation show more explicitly the strong impact of the radio lessons. For reasons

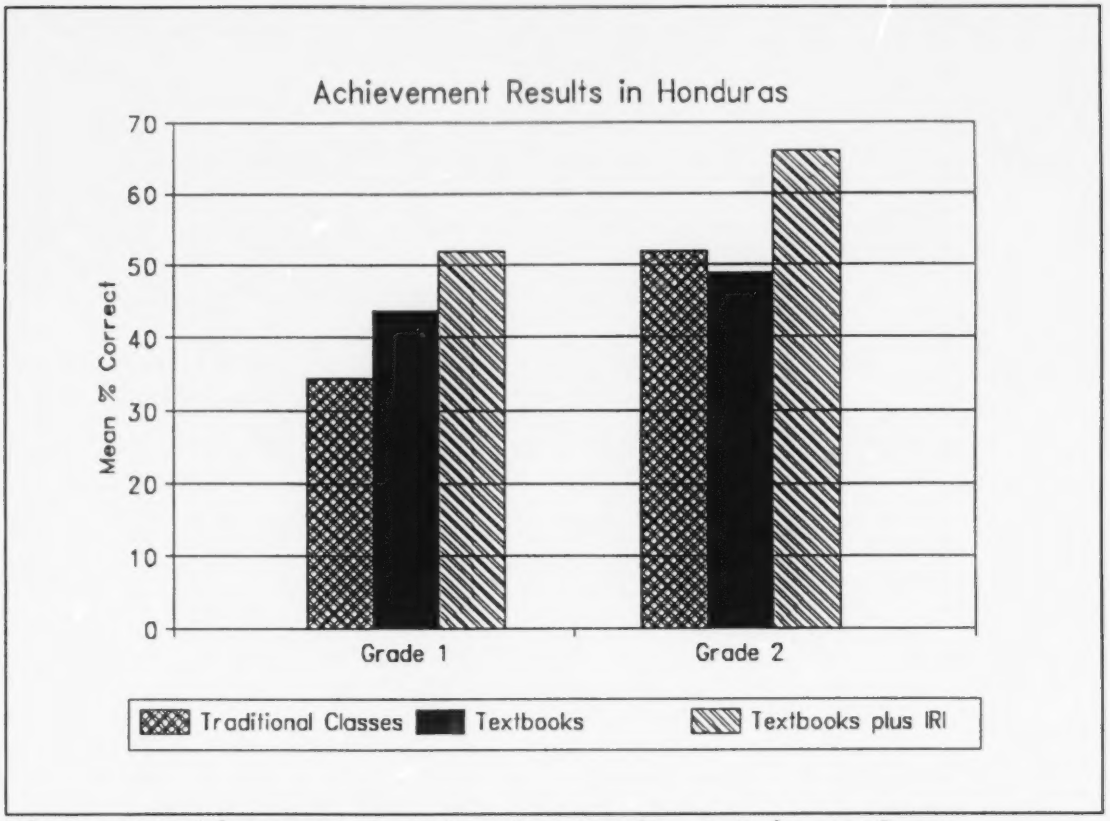

Figure 1 Achievement Results for Grades 1-2 in Honduras

that are not entirely clear, the textbook only group (Group B) actually shows a slight decline in achievement score as compared to the traditional classes (Group A). Apparently the Grade 2 textbooks arrived about half way through the year, and there were no teacher's guides nor special teacher training as was provided to the Grade 1 teachers. Whatever the reason, the new textbooks did not have a positive impact on achievement scores. Thus, the key scores are from the two groups of the lapped design (Groups A and C). The score of Group A was 52.0% correct; that of Group C was 63.5%. The effect size is .61. Since the textbooks had no effect, one can attribute the total gain of Group C to the radio lessons.

2. Cost study

a. Total Investment Expenditures

Total investment in this project from inception in 1987 through 1990 amounts to 6,930,952 Lempiras or US $3,465,476 using an exchange rate of US $1 = 2 Lempiras. Eighty-nine percent of

Table I Distribution of Total Investment Costs, Honduras

	Dollars ,000	Lempiras ,000
Development	1,982	3,964
Implementation	1,265	2,966
TOTAL	3,447	6,930

SOURCE: AVANCE, Academy for Educational Development, Education Development Center, and Friend Dialogues, Inc.

the costs were provided by the USAID/Honduras mission; 11% came from contributions from businesses in Honduras. These costs can be divided between expenses for <u>developing</u> the instructional materials and <u>implementing</u> the lessons in the schools. Table I shows the breakdown between these categories.

The preceding figures reflect the actual investment costs. A full costing of the development costs, however, requires that an opportunity cost be included. The use of available funds for creating *La Familia de los Números* was, theoretically, only one possible option. The money could have been used for other projects, or put into a bank to earn interest for future use. Therefore, an opportunity cost, sometimes referred to as a social discount rate, needs to be applied to the investment amount. Using an interest rate of 7.5% and a fifteen-year life for the radio lessons, the total investment was 7,716,141 Lempiras (US$3,858,071).[11]

b. Recurrent costs

The main question for this section is "What will it cost in 1990 prices to continue the implementation of *La Familia de los Números* to the current number of about 200,000 children?"

The budget allows for a staff of one administrator and four technicians to expand the use of the programs by ten percent per year; this staffing level allows for minor program changes, but not for major revisions nor for the development of new programs.

The recurrent costs based on 1990 prices with 200,000 students are presented in Table II.[12]

The annual recurrent cost is $1.01 per student. The largest single item is for radio transmission; other large items include the radios (amortized over five years) and the batteries. In addition, the cost for student notebooks is high.

An important consideration is the allocation of the costs among different constituencies or institutions. The costs can be allocated among three major groups: the Ministry of Education or

Table II Recurrent Costs, Honduras

	Dollars		Lempiras
AVANCE Adminis. Charge	16,750		56,963
Salaries and Benefits	37,503		127,510
Travel - Domestic	6,443		21,905
Radios & Print Materials	50,524		171,781
Radios		10,256	
Radio Repair		1,469	
Batteries		18,052	
Teacher's Guides		4,259	
Workbooks		14,388	
Posters		515	
Carrying Bag		115	
Supervisor Commission		1,469	
Transmission	78,824		268,000
Distribution	676		2,299
Teacher Training	7,101		24,144
Other Direct Costs	5,083		17,282
Total	$202,907		689,883
Cost Per Student 200,000 students	$1.01		3.45

AVANCE, the business sector, and the local community of parents and teachers. See Table III for a breakdown of these allocations. Of the $1.01 total recurrent cost, either AVANCE or the Ministry of Education will need to pick up $.40. Private businesses will assume $.43 per student. Of this cost, 94% is donated radio transmission time; the remaining amount is for printing half of the student notebooks, the plastic posters and the plastic carrying bags for the instructional materials. About 18% of the costs are to be met by parents or teachers. The breakdown of costs between parents and teachers depends of the circumstances in each school. These local community costs are for the radios, the repair of radios, batteries, teacher's guides, and about half the cost for the student notebooks.

The projected recurrent cost per student can be compared to the per student recurrent government expenditure. The latest figure in 1988 is 285 Lempiras per primary school student; assuming a growth rate of 15% to 1991, the total government expenditure per primary school student would be 328 Lempiras or US$96 (based on a US $1 = 3.4 Lempiras). The add-on cost to the Ministry of Education (e.g., $.40) to maintain La Familia de los Números would be only 0.4% of the annual per student recurrent

Table III Allocation of Costs, Honduras

	MOE or AVANCE	BUSINESS COMMUNITY	PARENTS/ TEACHERS
Administrative Overhead	16,754		
Salaries and Benefits	37,503		
Travel - Domestic	6,443		
Radios & Print Materials			
Radios	5,128		5,128
Radio Repair			1,469
Batteries			18,052
Teacher's Guides			4,259
Notebooks		7,194	7,194
Posters		515	
Carrying Bag		115	
Supervisors' Commission	1,469		
Transmission		78,824	
Distribution	676		
Teacher Training	7,101		
Other Direct Costs	5,083		
Total	$80,157	$86,647	$36,103
Cost Per Student 200,000 students	$0.40	$0.43	$0.18

government expenditure for primary education. If the total recurrent cost is considered (e.g., $1.01), the add-on cost is 1% of the government expenditure per primary school student.

c. Cost Effectiveness

Cost effectiveness is the ratio of the incremental gain in student achievement, stated in terms of effect size, to the incremental cost (e.g., recurrent cost) of the educational inputs.

The effectiveness measure for *La Familia de los Números* is difficult to calculate precisely because the radio lessons were introduced along with new textbooks that, in turn, were introduced with some teacher training (in Grade 1). In Grade 1, the effect size for the total package was .80, with the impact of IRI alone yielding an effect size of .37.

In the second grade, the impact of the total package was .61. But in contrast to the first grade, the addition of textbooks alone had no impact at all.

Therefore, the effectiveness measure to be used for the cost-effectiveness analysis is the average of the effect sizes for the two grades (.37 and .61) or .49. This represents the incremental learning as a result of the radio programs.

The per student recurrent cost for the radio programs is $1.01. Therefore, the cost-effectiveness ratio is .49.

d. Average Annual Total Cost

The total annual cost of the *La Familia de los Números* series is the sum of the development costs (including both the development of the materials and national implementation) amortized over fifteen years and adjusted for an opportunity cost or social discount rate of 7.5%. Table IV summarizes the total annual cost.

Table IV Total Annual Cost, Honduras

	Dollars
Development and Implementation Costs	$385,807
Recurrent Costs	$202,000
Total Annual Cost	$587,807
Cost per student	$2.94

If the opportunity cost is not included, the total cost per student would be $2.74.

Note that the combined development and implementation cost on an annualized basis is considerably larger than the recurrent costs. The costs for initial investment are an important consideration when assessing alternative interventions. Once the decision has been made to proceed and the development work has been completed, these costs can be considered as "sunk." That is, in terms of future decisions about expanding the implementation of the lessons and sustaining their use over a long time, the initial investment is irrelevant. Thus, although the per student cost is $2.94 when <u>all</u> costs are included, the incremental cost to continue the programs in the schools is only $1.01 per student.

B. Bolivia

1. Background

Bolivia is a poor, land-locked country in South America with topography ranging from the mountains and high plateaus of the Andes to the jungle lowlands to the East. Spanish is the official language, but the first language of the majority of the population is either Quechua or Aymara. As with many comparable nations, Bolivia is struggling just to survive economically. Lack of resources is evident everywhere including the primary schools.

In 1987 the USAID mission in La Paz decided to test out the application of IRI to improve the quality of primary school math instruction. After a successful pilot project, 405 lessons for Grades 2-4 were adapted from the Nicaraguan Radio Mathematics Project; a new series of 135 lessons is being created for Grade 5 in 1991. In addition, ten new IRI health lessons were piloted in 1989, and an expanded health series will be developed beginning in late 1991. The content of the math lessons spans all objectives of the official math curriculum.

The host institution is Fe y Alegria, a Catholic organization that administers about 300 primary schools on behalf of the Ministry of Education and Culture. The LearnTech Project[13] provided technical assistance. The lessons are now reaching about 50,000 children and the Ministry is developing plans to implement the IRI series on a national basis.

2. Achievement results

Summative evaluations of the impact of the radio lessons on student achievement have been conducted for Grades 2, 3 and 4. The results are now available for grades 2 and 3. For Grade 2 the introduction of interactive radio resulted in a jump of the average posttest score from 47.0% correct to 66.3%.[14] The effect size is .91. The impact on rural schools is particularly noteworthy. As shown in Figure 2, both groups of schools benefitted, but the improvement was more marked in the rural schools. In fact, with the intervention of the IRI lessons, the score of the rural schools exceeded those of the conventionally-instructed urban schools.

The results for Grade 3 are even more striking. The analysis compared the children who had radio math lessons for just one year (Grade 3 only) with those who had IRI two years (Grades 2 and 3). As can be seen in Figure 3, the children who had just one year of the IRI lessons did much better (51.9% correct) than the control group (35.0% correct). However, the score of the children who had the radio lessons for two years was even higher (61.6% correct). The effect size scores for both experimental groups (1.29 and 2.03 respectively) are

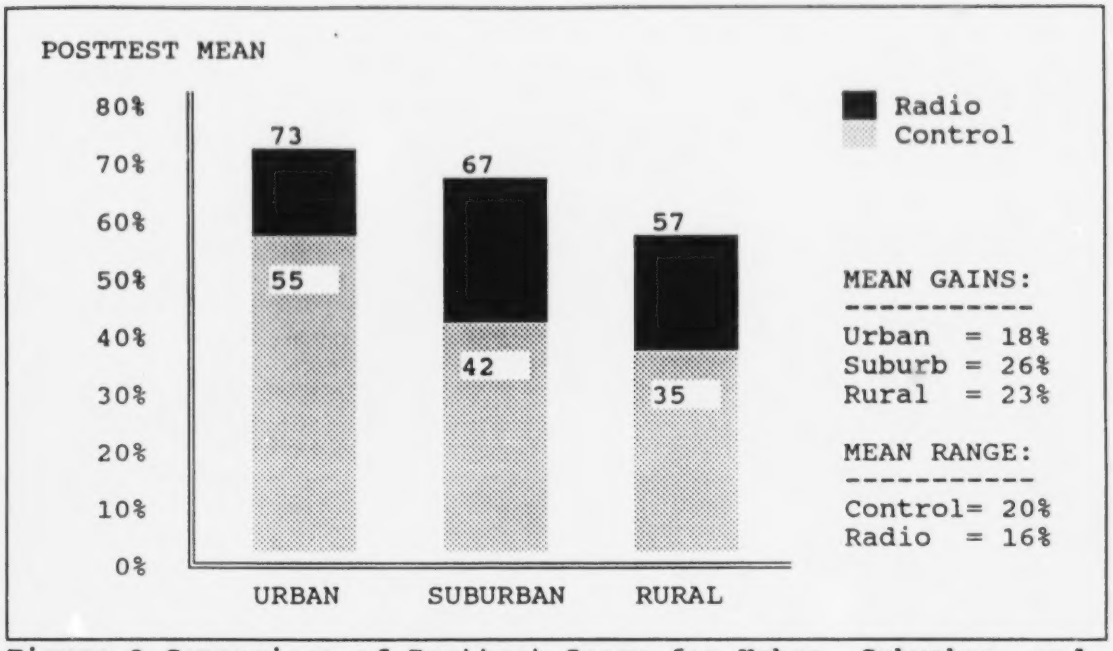

Figure 2 Comparison of Posttest Score for Urban, Suburban, and Rural Students

exceptionally high.

3. Cost-effectiveness study

a. Achievement

For this cost-effectiveness study, a new set of achievement data was collected to determine the relationship between learning gains and the amount of time studying mathematics in school. A test was developed from the pool of items used in the second and third grade tests reported on above. The test was designed to measure student mastery of objectives in the official Bolivian syllabus, not just the IRI curriculum. This test was administered about three-fourths of the way through the 1990 school year to 1,450 students in forty-eight second and third grade radio and control classes in Cochabamba.

By administering the same test to both grades, it was possible to assess the "normal" progression of learning over a year of both the experimental and control groups. In the control group, as expected, the children in Grade 3 scored significantly higher than the children in Grade 2. Overall, the scores were 22.5% correct for Grade 2 and 46.0% correct for Grade 3. The effect size was 1.7.

The scores from the radio classes were significantly higher

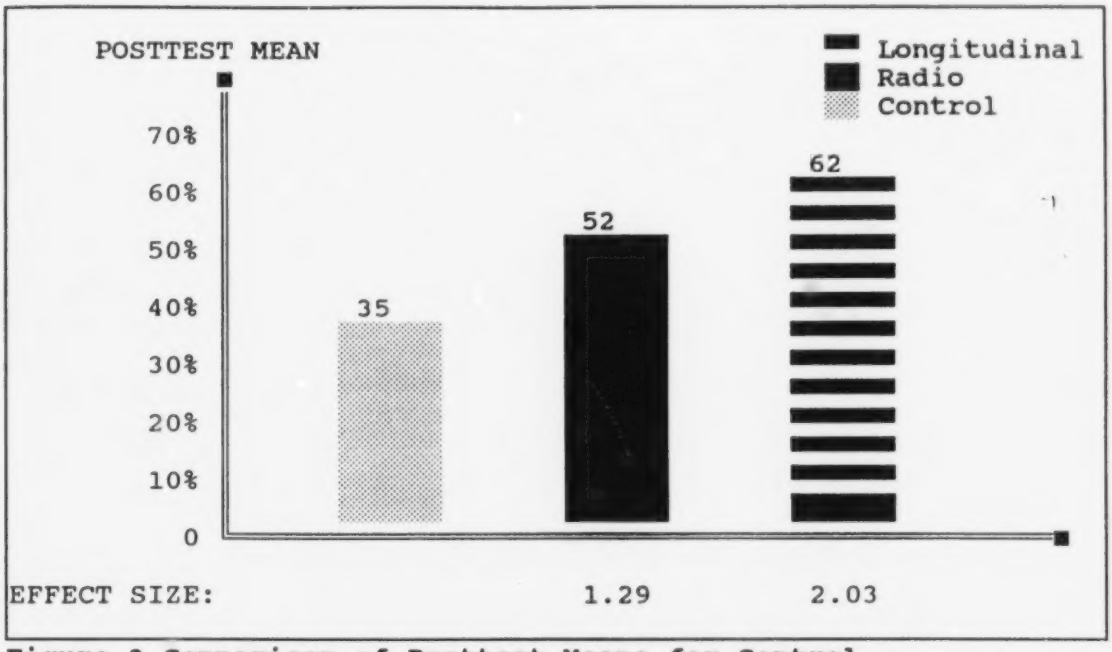

Figure 3 Comparison of Posttest Means for Control, Experimental, and Longitudinal Grade 3 Classrooms, Bolivia

Table V % Correct by Grade and Experimental/Control Group, Bolivia

	Grade 2	Grade 3
Conventional Schools	22.5	45.0
Radio Schools	35.0	61.5
Effect Size	.90	.90

for both Grade 2 and Grade 3 as shown in Table IV. The effect size for both grades was .90, although there was considerable variation by location of school. There was almost no difference in suburban schools for Grade 3 (effect size = .03); the largest difference was for Grade 2 rural schools (effect size = 2.1).

Another way to look at the data is to recognize that a score of 35.0% for the Grade 2 radio lessons is about half way between the Grade 2 and Grade 3 scores (22.5% and 46.0%). That is, by adding the radio lessons, the children learn about a half-year more as compared to children in conventional classes.

b. Costs

Given the positive impact of the radio lessons on mathematics achievement, the cost to attain a specified level of math achievement through radio classes may be reduced, if the cost of the radio lessons is not too high. The cost of the radio classes must include the costs of teachers, administration, schools, etc., plus the incremental cost of the radio lessons. The total cost per primary school student in Bolivia is $64. In Bolivia, mathematics is taught for six periods; thus, the pro-rated cost for math is $15.60. The radio-math classes take only five, rather than six, periods per week. Thus, the pro-rated cost to support the conventional component of the system is lower, $13. But to get the total cost of the radio classes, one must add the incremental cost of the radio system.

The radio costs can be divided between fixed and variable costs, that is, those costs that are fixed independently of the number of students and those costs that vary directly with the number of students. In Bolivia, the main fixed cost is the preparation of the math series. About $1.1 million was spent on developing 540 lessons resulting in a cost of about $2,100 per 30-minute lesson. In addition there were some startup costs. Assuming a 15-year life-time for the lessons, the annualized cost (with a 7.5% interest or discount rate) is $140,000.

Variable costs can be divided between capital and recurrent costs. The major variable capital cost is for radios. Assuming a five-year life for the radios, the annualized cost is $.11 per student. The variable recurrent costs are estimated at $.70 per student per year. Thus, the total annual cost is:

Total cost = $140,000 (fixed cost) + $.81 * N (variable cost), where N equals the number of students.

The total cost and the cost per student will vary depending

Table VI Cost for Radio Math by Number of Students, Bolivia

No. Students	Cost Per Student	Total Cost	Fixed Cost	Variable Cost
50,000	3.61	180,500	140,000	40,500
200,000	1.51	302,000	140,000	162,000
600,000 All Bolivia	1.04	626,000	140,000	486,000

on the number of students. The impact of three levels of implementation for Bolivia is shown in Table VI.

If N equals 50,000, the total variable cost is $40,500. Thus, this variable cost plus the fixed cost of $140,000 gives a total annual cost of approximately $180,500, or $3.61 per student. As the number of students using the program expands, the fixed cost per student decreases. If the project is expanded to include 200,000 children, the total cost per student drops to $1.51; with national implementation, the cost per student would drop to $1.04.

If we assume 200,000 children will use the programs, this would be in line with the current use in Honduras and Lesotho described in this paper, and would make comparison among the three countries easier. Thus, to arrive at a <u>total</u> cost of the radio math classes, one would add the incremental cost of the radio lessons ($1.51 based on 200,000 students) to the costs of the conventional system, which is $13.00. Thus, the total cost would be $14.51, which is less than the $15.60 of conventional instruction alone, assuming six periods a week rather than five periods that are used for the radio classes. And recall that the achievement level of the radio classes is markedly higher.

But once the materials are developed, the decision makers are mainly interested in the cost of implementing the project and maintaining it over the long term. These are the recurrent costs which total $.81. (In this analysis, the only fixed costs are for program development.) At this point the question is "Are there adequate resources to sustain the radio math series now that the lessons have been developed?" Once the international

Table VII Allocation of Recurrent Costs, Bolivia

	Allocation of Recurrent Costs	
	Ministry of Education	Parents/ Teachers
Radios	0.11	
Transmission	0.07	
Receiver power		0.04
Teacher's Guide	0.02	
Teacher Training	0.14	
Administration	0.18	
Student Notebooks		0.25
	0.52	.29

donors withdraw support for the IRI programs, hopefully after national implementation has been attaining, then Bolivia must meet the ongoing recurrent costs. These costs would be split between the Ministry of Education and Culture and the local communities (parents and teachers). Table IV shows the division of costs between these two groups.

c. Cost effectiveness

Most assessments of the cost-effectiveness of interventions to improve the quality of education in developing nations are determined by the ratio of the incremental gains in learning to the incremental costs; the incremental gains in learning are measured by effect size and incremental costs are stated in terms of U.S. dollars per student per year. In Bolivia, the cost effectiveness is determined by taking the effect size of .90 as a ratio to the incremental cost of $.81, resulting in a ratio of 1.10. As compared to the cost effectiveness of other interventions, the radio math programs seem to be a very attractive option.

The Jamison study, however, went beyond this usual analysis. He incorporated an additional cost-effectiveness analysis by measuring the ratio of the total learning gains to the total costs.

As discussed earlier, the effect size of one year of traditional study is 1.7. With a cost per student of $15.60, the cost-effectiveness measure is .11. The additional effect size from adding the radio lessons is .90, making a total effect size of 2.60. With a total cost of $14.51 based on 200,000 students, the cost-effectiveness ratio or efficiency is .18 for the IRI lessons. Thus, the cost-effectiveness of the IRI math classes is 64% higher than traditional math classes (based on the comparison between .11 efficiency for traditional math classes and .18 for radio classes). This figure would increase to 73% if the radio programs were implemented to all 600,000 students nationally. Therefore, the efficiency arguments for implementing IRI on a large scale are very strong.

C. Lesotho

The presentation of cost data from Lesotho is relevant because they help to determine the universality of the cost information collected in Bolivia and Honduras. Lesotho, a small, land-locked country, is located a continent away in southern Africa. Its 1.6 million people inhabit a mountainous area entirely above 5,000 feet in elevation. Much of its economic resources are derived from the majority of their male workforce who work in the mines in neighboring South Africa.

The primary school population is 314,000[15]. Classes are

very large at the lower primary level, especially in the urban schools. There is high drop out and repetition resulting in an efficiency ratio of 2.11. That is, for every graduate of the seven-year primary system, the government has paid for 14.78 years of schooling.

Interactive radio lessons were introduced there as part of the A.I.D. Basic and Non-Formal Education Systems (BANFES) Project. The IRI lessons help teachers teach English as a Second Language. English language skills are crucial to success in school because, after four years of schooling, English becomes the medium of instruction. In addition, it is essential to commerce in the region.

Many Basotho educators believe that the standards of English in the schools have declined in recent years. Thus, the English Division of the National Curriculum Development Centre decided to adapt the IRI lessons originally developed by the Radio Language Arts Project in Kenya. The new *English in Action* radio series is now being used in over 90% of the schools in Lesotho, reaching about 200,000 children in Standards (grades) 1-3. As the BANFES project closes down by mid-1991, the Ministry of Education is incorporating in their budget the recurrent costs for maintaining the IRI series.

The Lesotho lessons are similar to the IRI lessons being used in Latin America in that they are based on the interactive radio model, are about 25 minutes in length, and are broadcast every school day. There is an important administrative difference, however. In Lesotho, the project was developed and is being implemented within the Ministry of Education and the lessons are broadcast by the government-owned national radio station. In both Bolivia and Honduras, the development efforts were based in private institutions and the lessons are broadcast by privately owned radio stations. In all three countries, the development costs were funded by the U.S. Agency for International Development. Given the differences between the situation in Lesotho and that in Bolivia and Honduras, an important question is whether there are any corresponding differences in the cost structure for developing and implementing the radio lessons.

1. Context

The costs for the *English in Action* series for grades 1-3 in Lesotho can be divided between development and incremental costs. The development costs include the expenditures for adapting the radio series from the Radio Language Arts Project (RLAP) programs, originally created in Kenya, to the curriculum and culture of Lesotho. Only minor changes of the scripts were required before the lessons were re-recorded. The incremental costs are those expenses above and beyond the normal expenditures

for schools that would be required to sustain the radio programs on a national basis for a long period of time.

This section summarizes the developmental and incremental costs, and the total annual costs of the series. In addition, the costs per student are presented. Finally, the allocation of the incremental costs to various groups (Ministry of Education, Ministry of Information and Broadcasting, and parents and teachers) is shown.

2. Development costs

Table VIII presents the development costs for adapting the 525 lessons for Standards 1-3.

Table VIII Development Costs, Lesotho

Personnel	
Host Country	96,201
Technical Assistance	447,931
Furniture and Equipment	33,319
Operational Costs	98,023
Summative Evaluation	45,624
@ 0% Discount Rate	721,098
@ 7.5% Discount Rate	1,225,367

The total expenditure was $721,098. For this analysis a 7.5% discount rate was used. The full development cost with a 7.5% discount rate was $1,225,367.

Once the total development costs have been determined, it is necessary to average this amount over the useful life of the radio lessons. Assuming a 15-year life for the lessons, the average annual development cost is $48,073, or $81,691 including a 7.5% discount rate.

Table IX Student Enrollment, Lesotho

	Enrollment in 1990
Standard 1	80,481
Standard 2	63,420
Standard 3	56,972
Total	200,873

3. Incremental Cost

The incremental recurrent cost for adding IRI to the schools in Lesotho is composed of both fixed and variable costs.

The variable costs depend on the number of students. In Lesotho, the number of students in Standards 1-3 is shown in Table IX.

Table X shows the total annual fixed and variable costs.

The fixed costs account for 25% of the total incremental costs; 87% of the fixed cost is for transmitting the lessons. Of the variable costs, the replacement of batteries is the most significant component (40%); the student workbooks account for 28% (these are depreciated over three years) and the radios account for 25% (depreciated over five years).

Given the high cost of batteries, an estimate was made on how much this component might be reduced if Ni-cad rechargeable batteries were used and the recharging was provided by a solar panel. Such an arrangement would reduce the total battery cost by one-half, and the total incremental cost by 15%.

Table X Total Fixed and Variable Costs

TOTAL INCREMENTAL COSTS: STANDARDS 1-3	COST	PERCENT
FIXED COSTS		
Radio Transmission	41,490	87%
Administration	6,100	13%
Subtotal	47,590	
VARIABLE COSTS		
Radio Receivers	34,603	25%
Radio Maintenance	2,625	2%
Batteries	55,997	40%
Teachers Guides	4,943	4%
Student workbooks	39,127	28%
Teacher Training	1,481	1%
Delivery of materials	1,842	1%
Subtotal	140,618	
TOTAL INCREMENTAL COST	188,208	

As shown in Table XI, the incremental cost per student is $.94. This represents 1.7% of the total expenditures per primary school pupil. The total cost per primary school student is $55., of which the Ministry of Education budget covers $24; the remainder is provided by churches or local communities.

4. Allocation of Costs

Although the incremental cost per student is $0.94, the Ministry of Education does not pay this amount. The costs are allocated among the Ministry of Education, the Ministry of Information and Broadcasting, and the parents (with the teachers picking up some of the costs in some schools). The allocation of costs is shown in Table XI.

The Ministry of Information and Broadcasting finances Radio Lesotho, which broadcasts the *English in Action* series without

Table XI Allocation of Costs for *English in Action*, Standards 1-3, Lesotho

ENGLISH IN ACTION
STANDARDS 1 - 3

		Allocation of Incremental Costs		
	Total Costs	Ministry Education	Ministry Inform.	Parents Teachers
Workbooks	$39,127	$39,127		
Teacher training	$1,481	$1,481		
Teacher's guides	$4,943	$4,943		
Radio receivers	$34,603	$24,847		$9,756
Maintenance of radios	$2,115			$510
Power, battery	$55,997			$55,997
Radio transmission	$37,500		$37,500	
Duplication of worn tape	$3,990	$3,990		
Administrative & clerical	$3,600	$3,600		
Administrative overhead	$2,000	$2,000		
Administrative travel	$500	$500		
Delivery of materials	$1,842	$1,842		
Total Program Cost	$188,208	$84,445	$37,500	$66,263
Cost Per Student	$0.94	$0.42	$0.19	$0.33
200,873 students				

charge. Although Table XI shows that the cost to the Ministry of Information and Broadcasting for transmitting the lessons on Radio Lesotho is $37,500, in reality the budget of the Ministry will be little affected as the *English in Action* radio programs simply replace other programs.

The parents, perhaps with some participation by teachers, buy the radios (at a subsidized price) and the batteries; they also pay for the repair of the radios. On average, they provide $0.33 per student or a total of $66,263 per year.

The remaining expenditures must be covered by the Ministry of Education. On the average each year (in 1990 U.S. dollars), the Ministry must budget $.42 per student, or a total of $188,208, to the radio English lessons. This represents 1.8% of the budget for primary education. In the first years, the amount will be less than this as the radios, teacher's guides, and student workbooks are new and will not need to be replaced immediately.

5. Total Cost

The total cost of the radio series for each year is the sum of the development costs (with a 7.5% discount rate and averaged over fifteen years) plus the annual incremental cost.

Total Annual Cost = Annualized Development Cost + Annual Incremental Cost

The annualized development cost is $81,691. The total incremental cost for one year is $188,208, for a total annual cost of $269,899 or $1.34 per student.

V. Similarities and Differences of Costs in Honduras, Bolivia and Lesotho

The development and implementation costs for the interactive radio projects in Central America, South America and southern Africa are remarkably similar. The development cost in Honduras was higher, but this would be expected as a new curriculum was created. All the IRI lessons in Lesotho, and about two-thirds the lessons in Bolivia, are modifications of programs developed in other countries. Thus, their development costs are lower.

Table XII Recurrent Incremental Cost: Honduras, Bolivia and Lesotho

Country	Recurrent Incremental Cost	MOE Cost	Percent MOE Budget
Bolivia	$0.81	$0.52	0.8%
Honduras	$1.01	$0.40	0.4%
Lesotho	$0.94	$0.42	1.8%

The recurrent costs for all three countries are remarkably similar, ranging from $.81 to $1.01 per student per year. Table XII summarizes the recurrent incremental costs assuming that about 200,000 children in each country use the programs each year.

Yet when one looks more closely at the allocation of recurrent costs among cost categories, there is considerable variation. The pie graphs in Figures 4-6 show the distribution of costs in each of the three countries. The bar graph in Figure 7 compares the allocation of costs by percentage among the countries. For example, the administration costs range from 6% in Lesotho to 28% in Honduras; the cost of receiver power (batteries and electrical utility) range from 5% in Bolivia to 30% in Lesotho; and teacher training ranges from 3% in Lesotho to 20% in Bolivia.

Graphs showing the allocation of recurrent costs are seen

in Figures 4-6. Some of the differences are due to the conditions within each country. For example, virtually all schools in Lesotho have to rely on batteries for the radio receivers, and the cost of batteries is higher than in the other two countries. In Bolivia only 50% of the schools need to use batteries. Other differences reflect decisions of the project administrators. Bolivia, for example, puts a relatively high emphasis on teacher training. The administrative expenses in Honduras are relatively high because AVANCE wants to maintain a staff large enough to modify some of the radio programs.

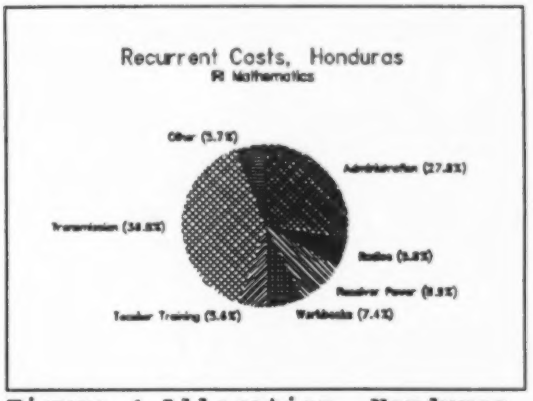

Figure 4 Allocation, Honduras

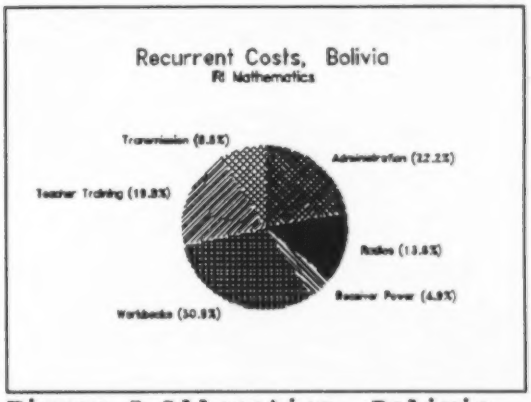

Figure 5 Allocation, Bolivia

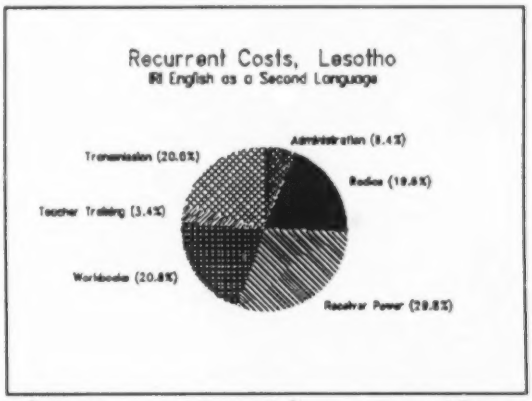

Figure 6 Allocation, Lesotho

Although the <u>total</u> recurrent cost per student doesn't differ greatly among the three countries, we see that there are considerable differences in the <u>allocation</u> of costs. There is another significant difference as well. There is a large difference in the *percentage of the Ministry of Education budget that is required to sustain the programs*. In Honduras, it is only .04%; in Bolivia, it is .08%; and in Lesotho, it is 1.8%. Thus, in terms of the impact on the Ministry of Education budget, the cost is significantly higher in Lesotho.

Some of these differences may have an impact on the long-term sustainability of the programs. Does extra attention to teacher training (including teacher's guides) as in Bolivia result in more long-term support of the teachers? Does retaining at least a minimal production staff, as AVANCE had planned, maintain a vitality of the radio system that is necessary? Will the high cost of batteries in Lesotho result in abandonment of the program? It is too early yet to answer these questions, but

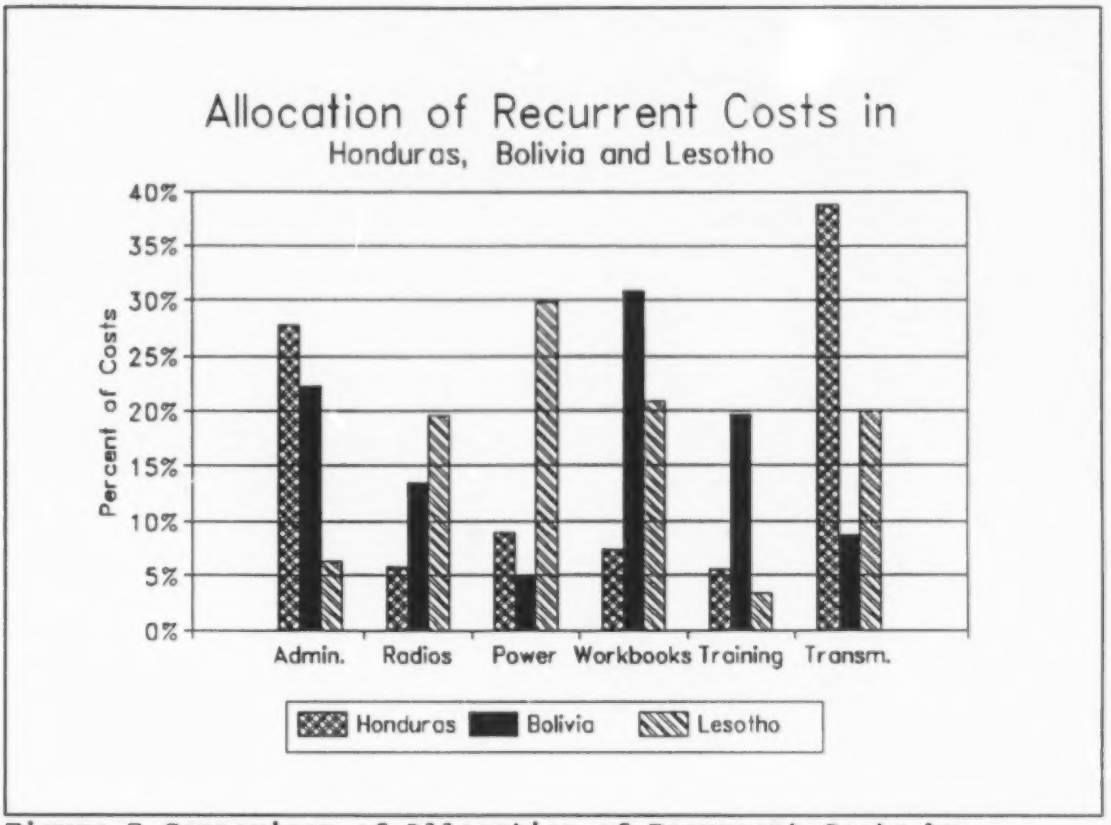

Figure 7 Comparison of Allocation of Recurrent Costs by Category and Country

it is not too early to begin designing studies that will go beyond the gross measures of costs. These new studies should examine the implications of policy and related cost decisions on long-term sustainability.

VI. Comparison of IRI with Textbooks and Teacher Training

The summative evaluation data from Honduras and Bolivia demonstrate that IRI is a powerful intervention for improving mathematics achievement in the early grades of primary school. When the costs and achievement data are combined in these two countries, the results show a strong cost-effectiveness ratio. For Honduras, the ratio is .49 and that for Bolivia is an impressive 1.10. But to appreciate more fully the cost-effectiveness of IRI, it is useful to compare IRI with other interventions, specifically the introduction of textbooks and teacher training. Lockheed and Hanushek[16] present comparative cost-effectiveness data (what they call efficiency) on three IRI projects, two textbook projects, and four teacher training projects. Figure 8 presents their findings plus the data from

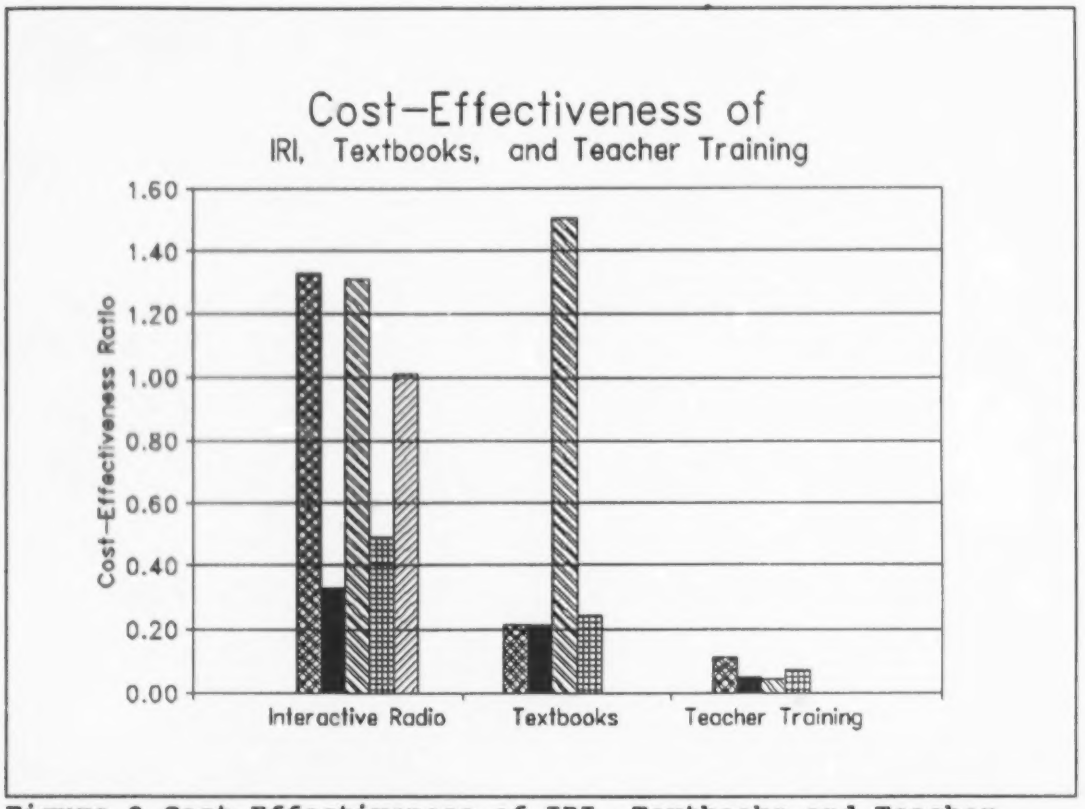

Figure 8 Cost-Effectiveness of IRI, Textbooks and Teacher Training

the Bolivian and Honduran IRI projects reported on in this paper.

These data show that interactive radio is a powerful instructional tool, possibly even more cost-effective than textbooks or teacher training. With one exception in their study, the cost-effectiveness of introducing textbooks is less than IRI. The low cost-effectiveness ratio for teacher training is due to the combination of high costs and low effectiveness.

VII. Conclusions

In 1990 cost studies were carried out on interactive radio programs in Honduras, Bolivia and Lesotho. The cost for developing a new three-year radio math series in Honduras was $1.982 million; the cost in Bolivia for adapting three years of math lessons and creating programs for a fourth year was $1.135 million; and the cost for adapting three years of English lessons in Lesotho was $721,098. Thus, as one would expect, there are considerable cost savings for adapting programs from one country to another as compared with creating a new series of lessons.

The annual recurrent cost per student did not show a large variation among the three countries ($0.81 in Bolivia, $0.94 in Lesotho, and $1.01 in Honduras. However, the allocation of those costs among expense categories varied widely. The costs for teacher training, for example, ranged from a low of 3% in Lesotho to a high of 20% in Bolivia. These differences, which may be attributable in part to special circumstances in each country or to policy decisions by project administrations, may have an important impact on long-term sustainability of the IRI programs, but it is too early to know.

Another important difference appears when one examines the percentage of the Ministry of Education budget that would be required to sustain the programs. In Honduras and Bolivia this is 0.4% to 0.8% respectively, but the figure for Lesotho is much higher, 1.8%. Thus, the IRI programs in Lesotho will have a relatively higher impact on the Ministry of Education and, thus, could also affect long-term sustainability.

This paper also examined the relationship between costs and student learning gains. Since the IRI lessons do represent an add-on cost for schooling in each country, it is crucial to be able to relate those costs to increased learning. In Honduras and Bolivia, the achievement gains of the children as a result of the IRI programs are dramatic. We also know that the English programs in Lesotho were adapted from the IRI series in Kenya where increased learning was also striking. When the costs and achievement data are combined in Honduras and Bolivia, the resulting cost-effectiveness ratios, .49 and .90 respectively, are high. Thus, the increase in investment results in significant gains in learning.

To appreciate more fully the impact of IRI programs, the paper concludes with comparative data among three types of interventions--interactive radio, textbooks, and teacher training. Based on the studies presented, IRI appears to be the most cost-effective intervention, with the introduction of textbooks in second place. Teacher training programs may fall way behind in terms of a cost-effective way to increase student learning.

In summary, IRI should be considered along side of textbooks and teacher training when educational planners and decision makers are considering options for improving basic education. It's high effectiveness and reasonable cost make it an excellent option, either independent of or together with other interventions.

4/1/91

Endnotes

1. The studies in Bolivia, Honduras and Lesotho were conducted by the Radio Learning Project with additional support from the World Bank. These studies are presented in more detail in Lockheed, M., Middleton, J., Nettleton, G. (Eds). Technology and Teaching: Elements of Sustainability in Developing Countries (Draft). Washington, D.C.: The World Bank, 1990.

2. Zirker, Joan. Interactive Radio Instruction: Confronting Crisis in Education, Newton, MA.:Education Development Center, 1990. Friend, J., Searle, B., Suppes, P. (Eds.) Radio Mathematics in Nicaragua. Stanford, CA.:Stanford University, 1980. Imhoof, M. and Christensen, P (Eds.) Teaching English by Radio: Interactive Radio in Kenya. Washington, D.C.:Academy for Educational Development, 1986. Eshgh, R., Hoxeng, J. and Casals, B. (Eds.) Radio Assisted Community Basic Education (RADECO). Pittsburgh: Duquesne University Press, 1980. *Development Communication Report*. Radio Learning Project: Reprint of articles from the *Development Communication Report*. 1988.

3. McNally, K. *Los Costos de la Instrucion en Nicaragua*, 1978?. Kemmerer, F. and Friend, J. *Strategies for and costs of disseminating the Radio Language Arts Project throughout Kenya*, Washington, D.C.: Academy for Educational Development, 1985. Donald R. Winkler, *Economic Analysis of Radio Education: Evaluation of a Proposal to Use Radio to Teach Mathematics in the Dominican Republic, 1984-1989*, USAID/Santo Domingo, 1984.

4. Godoy-Kain, Patricia. *Evaluation of Development and Recurrent Costs for "La Familia de los Números,"* Washington, D.C. Development Technologies, Inc., 1990 under a contract with Education Development Center as part of the Radio Learning Project.

5. Jamison, Dean T., *The Radio Mathematics Project in Bolivia: A Cost-Effectiveness Evaluation*, Newton, Ma.: Education Development Center, 1990.

6. The cost study was carried out by this author in collaboration with Maurice Imhoof. A more complete report can be found in Imhoof, M. and Tilson, T., *Lesotho Radio Language Arts Program*, Newton, MA: Education Development Center, 1990.

7. Lockheed, M.E. and Verspoor, A.M. *Improving Primary Education in Developing Countries: A Review of Policy Options*. (Draft) Washington, D.C.: The World Bank, 1990. P. 8

8. Sanguinetty, J. *The Replication of the RADECO Project in the Dominican Republic: Recurrent Cost Implications*. Washington, D.C.: Development Technologies, Inc., 1985

9. Friend, J., Beach, K., Kozlow, S., Gamero, G., and Galda, K. *The Impact of Honduras Mental Arithmetic Radio Programs on Student Achievement in Grades 1 & 2*. Shelby, N.C.: Friend Dialogues, 1990.

10. Effect size is a statistical measure that is particularly useful for comparing different types of interventions. It is calculated by taking the difference of the mean scores between the experimental and control groups and dividing by the standard deviation of the control group.

11. The study from which these data were taken assumed a 17% discount rate and a project life of ten years. Given these assumptions, the total investment cost was 8,418,727 Lempiras or $4,209,364.

12. The costs in dollars are based on an exchange rate of US $1 = 3.4 Lempiras. Note that this is a different rate than that used for the development costs presented above. The reason for the change is that during all but the last few months of the development phase of this project, the exchange rate was approximately 2 Lempiras per dollar. Beginning in January, 1990, the Lempira began to be devalued, reaching 5.5 Lempiras per US dollar by mid-September when these data were collected. Thus, the impact of the devaluation on local costs of imported goods had not been fully realized when these data were collected. Therefore, the development costs of the project are stated in terms of the predominant existing exchange rate at that time of US $1 = 2 Lempiras. The recurrent costs, however, are stated using 3.4 Lempiras per dollar. The 3.4 rate is calculated using a combination of two rates; the rate of 5.5 Lempiras per dollar is applied to costs not tied to imported goods, and a rate of 2 Lempiras is applied to items that are imported and, thus, must be paid in dollars.

13. The LearnTech Project is funded by the U.S. Agency for International Development (A.I.D.) to support the appropriate use of learning technologies to improve basic education in developing countries. The project is administered by an international consortium headed by the Education Development Center (EDC), Newton, Massachusetts. LearnTech is a follow-on project to Radio Learning Project, also funded by A.I.D. to a consortium led by EDC.

14. Fryer, M. and Jamison, D. *"Math and Health Education Through Interactive Radio: The Bolivian Radio Education Project,"* prepared for the World Bank, September 28, 1990.

15. Based on 1985 World Bank data.

16. Lockheed, M. E. and Hanushek, E., *Improving Educational Efficiency in Developing Countries: What Do We Know?* Compare, vol. 18, no. 1 (1988), p. 21.

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